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A PLAN FOR AN INDEPENDENT SOVIET LATITUDE SERVICE

By V. K. Abol'd

[NOTE: Numbers in brackets refer to the bibliography.]

In one of my works [1] I mentioned the Greenwich latitude station as an example of how one station can control the whole world should there be established at that station a longitude service or a universal azimuth service, in addition to latitude observations. This means that from observations conducted at this station a corresponding $\Delta\varphi_i$, which is necessary for determining the mean latitude φ_0, may be obtained for any point of the earth's surface whose φ_i has been ascertained.

In addition, φ_0 will be absolutely related to the one and the same polar mean (the origin of the system of right-angle coordinates) chosen arbitrarily by this station.

The system of an independent Soviet latitude service, which does not require international cooperation and which I decided to bring to the attention of Soviet astronomers, is based on this.

Based on current methods (other conditions being equal), and in view of the feasibility of using simpler instruments (telescopes without horizontal turning axes), it is my opinion that only 50 percent of the capital needed to equip a corresponding latitude service is needed to realize this system.

For the sake of brevity, I later on refer to the usual determinations of a latitude as absolute, according to which observations of stars are conducted when the zenith telescope is placed in two positions. In order to determine variations in the latitude, I suggest that the stars be observed without a resetting of the instrument and the results of such observations be called relative determinations of latitude.

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In connection with the Soviet latitude service, observations should be conducted at least at two stations.

One station (the main station), in addition to observing the absolute and relative determinations of latitude, is engaged in azimuthal determination of one polar coordinate (y), while the second station (substation) limits itself to the relative determination of latitude and azimuthal determination of the second polar coordinate (x).

Azimuthal determination of polar coordinates, apparently being more easily realizable than longitudinal locations of polar coordinates, is specified in the system I suggested.

The difference in longitudes of the above-mentioned stations should be as close as possible to 90 degrees so that reductions to an ideal meridian would be close to zero.

In order to avoid setting up stations in new places, it is possible, in my opinion, to limit ourselves to combinations of Pulkovo-Irkutsk or even Poltava-Irkutsk stations. Reductions of these stations to the meridian λ = 270 degrees -- for the purpose of obtaining (-y) according to the formulas in Tables 2, 10, and 11 [1] -- result in the following:

Pulkovo (main station $\lambda = 0° 0'$), Irkutsk (substation $\lambda = 286° 0'$)

For latitudinal observations r270 = -0.276x - 0.039y
For longitudinal observations r270 = -0.050x + 0.356y
For azimuthal observations r270 = 0.064x - 0.451y

Poltava (main station $\lambda = 0° 0'$), Irkutsk (substation $\lambda = 290° 14'$)

For latitudinal observations λr270 = -0.346x - 0.062y
For longitudinal observations λr270 = -0.080x + 0.146y
For azimuthal observations λr270 = 0.101x - 0.565y

Here, x and y are arbitrary designations for the polar coordinates.

It must be noted that even though the presence of a substation is not required, it is apparently very desirable because its existence insures the possibility of checking results of the determinations of the polar coordinates obtained by various methods.

If the meridian of the main station is taken as the primary meridian, and if the west longitude of the substation is equal to 270°, the following equations given in formulas of Table 9 in [1] are obtained:

$$\left.\begin{aligned} \varphi &= \varphi_0 + x, \\ \varphi + M_x &= \varphi_0 + x, \\ a &= a_0 + y \sec \varphi \end{aligned}\right\} \qquad (1)$$

on the basis of which, observations of the main station are expressed in the following manner on the polar coordinates:

$x_i = \varphi_i - \varphi_0$ (absolute determination of the latitude)
$x_i = \varphi_i' + M_x - \varphi_0$ (relative determination of the latitude) (2)
$y_i = (a_i - a_0) \cos \varphi$ (azimuthal determination of the polar coordinates)

On the bases of the following equations

$$\left.\begin{aligned} \varphi' + M_x &= \varphi_0 - y, \\ a &= a_0 + x \sec \varphi \end{aligned}\right\} \qquad (3)$$

the following control values are obtained from observations conducted by the substation according to formula (9) cited in [1]:

$$y_i = \varphi_0 - (\varphi_i' + M_z) \text{ (relative determination of latitude)}$$
$$x_i = (a_i - a_0)\cos\varphi \text{ (azimuthal determination of polar coordinates)} \quad (4)$$

In these formulas x and y represent polar coordinates; φ and φ_0, momentary latitude and mean latitude; a and a_0, momentary and mean azimuth of the universe, respectively; M_z, point of zenith; and φ_i', an average reading of the micrometer adjusted to the inclination of the vertical axis, curvature of the parallels, and refraction and declination of the hair, providing the observations are conducted by the hour-angle method. If observations of stars are made with fixed hairs, adjustments must be made for a collimation error and the azimuth.

Thus, the formula for relative determination of altitude must read:

$$\varphi_i' + M_z = \varphi_i$$

In this instance φ_0, and M_z are invariable quantities.

Determining the Absolute φ_0, a_0 and M_z

The mean value obtained after many years of observations should be used for φ_0 and a_0 (in connection with equations (1) and (2)) at the main station so that the origin of the coordinates would coincide as closely as possible with the polar mean used in international latitude service. If such values are lacking, we may confine ourselves to the following formula (5):

$$\varphi_0 = \tfrac{1}{2}(\varphi_{min} + \varphi_{max}),\ a_0 = \tfrac{1}{2}(a_{min} + a_{max}) \quad (5)$$

Mz is established as the mean from sufficiently large numbers of simultaneous determinations of differences $(\varphi_i - \varphi_i')$.

At the substation, a_0, which enters into equations (3) and (4), is expressed in the following formula after proper observations of a_i by the substation and x_i by the main station:

$$a_0 = a_i - x_i \sec\varphi \quad (6)$$

Two cases should be distinguished when establishing M_z:

1) When the value of φ_0 is known.

Since the moments when y_i turns to zero are known (as a result of observations made by the main station), the value of M_z is determined by

$$M_z = \varphi_i - \varphi_i', \text{ when } y_i = 0 \quad (7)$$

2) When the value of φ_0 is not given.

In this instance $\varphi_i' = (\varphi_0 - M_z) - y_i$. (8)

That is to say, observations of φ_i' are distinguished from the value $(-y_i)$ by an invariable quantity $(\varphi_0 - M_z)$, the value of which may be found by the main station with the aid corresponding values of y_i, by using the following formula:

$$\varphi_0 - M_z = \varphi_i' + y_i \quad (9)$$

Since the values of the invariables have been established, the net of two stations describes: 1) one series of values for x_i by employing the

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absolute method; 2) One series of values for the pair (x_1, y_1) by employing the relative method; and 3) One series of values for the pair (x_1, y_1) by employing the azimuthal method.

The factors necessary for exact location of geographic coordinates, $\Delta\varphi = \varphi - \varphi_0$, $\Delta\lambda = \lambda - \lambda_0$ and $\Delta a = a - a_0$, are established (with the aid of known equations (10)) for any point on the earth's surface when the west longitude, which is relative to the main station, equals

$$\left.\begin{aligned} \Delta\varphi &= x\cos\lambda + y\sin\lambda, \\ \Delta\lambda &= (x\sin\lambda - y\cos\lambda)\tan\varphi, \\ \Delta a &= (y\cos\lambda - x\sin\lambda)\sec\varphi \end{aligned}\right\} \qquad (10)$$

Observations and Instruments

The program for absolute determination of latitudes must contain only zenith stars singly or in pairs. Only special zenith telescopes must be used in observations (instruments similar to those installed in Greenwich and Getersborg or models suggested by me [2].

The same applies to the relative determinations of latitudes. Since in this case observations of stars are conducted without resetting the instrument, the design of the instrument can be greatly simplified. A sufficiently powerful telescope, equipped with an ocular micrometer which is firmly and permanently attached to a stone pillar so that the line of vision of the telescope would be vertical, will probably be sufficient for obtaining relative determinations of latitudes. The declination of the line of vision should be controlled by sensitive overhead levels. It is desirable to watch (with the aid of special apparatus) for possible strains on the pillar.

All zenith stars within the reach of the telescope should be observed.

In my opinion it is simpler to obtain azimuthal determinations of the polar coordinates with the hair of the micrometer set on Polaris during its adjustment. The described telescope may serve the purpose.

In this case the telescope should be mounted in such a manner as to have its line of vision set on Polaris.

Thus, in order to realize absolute and relative determinations of a latitude and azimuthal determinations of polar coordinates, it is necessary to mount three telescopes on a firm stone foundation shaped in the form of a parallelepiped, with a depression on its upper surface. Telescopes designed for latitude observations are firmly attached to the western and eastern sides of the pillar, and their lines of vision must be vertical. For the telescope used for absolute latitudinal observations, it is necessary to provide for a resetting of the tube, such as rotating it around its vertical axis. The depression on the surface of the piller serves for mounting the third telescope so that its line of vision would be directed to the North Star. The arrangement of three telescopes described above is illustrated in the schematic drawings shown in Figure 1.

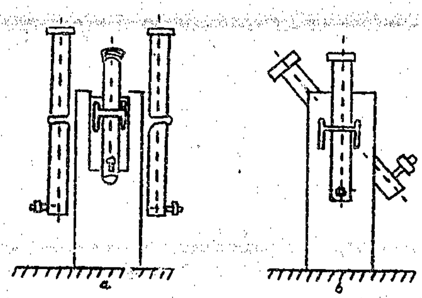

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Figure 1

Two telescopes are mounted on a same kind of foundation at the substation. The possibility of setting up a third telescope for absolute observations, which can be transported from the main station for temporary control observations, is foreseen. In the absence of this telescope, its place is occupied by a counterweight.

The ocular micrometers of the above-mentioned telescopes can be replaced easily with either moveable or fixed adapters for photographic plates. The diameter of the object lens of the above-mentioned telescopes must be at least 150 mm.

On the basis of the above system for an independent Soviet latitude service, the basic equipment consists of a pavillion with a massive stone pillar to which three 6- to 7-inch telescopes are secured at the main station and a similar pavillion with two telescopes at the substation.

In conclusion, I would like to draw attention to the following. If it will be possible to install a telescope for determining the relative locations of a latitude so accurately the M_z will become a sufficiently invariable quantity, the need for a regular determination of absolute locations of a latitude will then be eliminated. It will only be necessary to do this periodically, and then only to check the position of M_z.

In the event that there are two main stations, the conversion from a fixed pole of one station to that of the other station is done with the aid of simple formulas.

Let us designate the polar coordinates obtained at these stations as (x, y) and x' ,y') respectively. Let us assume that as a result of simultaneous observations made by a third station (φ, λ, a), reduced to the nearest fictitious meridians, the following has been obtained for longitudes equivalent to 0, 90, 190, and 270°, $(\Delta\varphi, \Delta\lambda, \Delta a)$ $(\Delta\varphi, \Delta\lambda, \Delta a)$

By introducing symbols $x'-x=\delta x$, $y'-y=\delta y$, $\Delta\varphi'-\Delta\varphi$, $\Delta\lambda_2-\Delta\lambda$, we will obtain the following necessary formulas for conversion from one pole to another:

$\delta\Delta\varphi = \pm\delta x$	plus signs employed when	0°
$\delta\Delta\lambda = \pm\delta y \tan\varphi$	minus signs employed when	180°
$\delta\Delta\lambda = \pm\delta y \sec\varphi$		
$\delta\Delta\varphi = \pm\delta y$	plus signs employed when	90°
$\delta\Delta\lambda = \pm\delta x \tan\varphi$	minus signs employed when	270°
$\delta\Delta a = \pm\delta x \sec\varphi$		

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